PORPHYRA AND *PORPHYROPSIS* (RHODOPHYTA) IN SOUTHERN AUSTRALIA

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Summary

WOMERSLEY, H. B. S., & CONWAY, Elsie (1975).—*Porphyra* and *Porphyropsis* (Rhodophyta) in southern Australia. *Trans. R. Soc. S. Aust.* **99**(2), 59-70, 31 May, 1975.

Two epilithic species of *Porphyra*, *P. columbina* and *P. lucasii*, occur on southern Australian coasts, mainly during winter; their seasonal morphology and distribution are described. One epiphytic species, the little-known *P. woolhousiae*, is described from additional collections, some of which are reproductive. *Porphyropsis minuta* sp. nov., epiphytic on *Pterocladia capillacea* and other cartilaginous red algae, is also described.

Introduction

Porphyra is common during winter on the south-eastern coast of Australia, and a brief account of *P. columbina* Montagne and *P. lucasii* Levring was given by Levring (1953). Both these species occur on rock or firm substrates and are monostromatic with a single rhodoplast per cell. Levring also described *P. denticulata* Levring from Queensland, recorded *P. naiadum* Anderson (now *Smithora naiadum* (Anderson) Hollenberg) from New South Wales, and repeated the original record of *P. woolhousiae* Harvey from Tasmania.

Since it is largely a winter form, *Porphyra* has often been omitted from ecological accounts. *P. umbilicalis* (=*P. columbina*, from Cribb 62.5 in ADU) was, however, recorded by Cribb (1954, p. 30) as forming an almost pure association during winter and spring, on fairly rough-water coast at Port Arthur, Tasmania, and *P. columbina* was recorded by Guiler (1954, p. 64) from Blackman's Bay (near Hobart), Tasmania. Womersley & Edmonds (1958, p. 247) recorded *P. columbina* and *P. umbilicalis* (=*P. lucasii*) as winter forms, mainly on the south-eastern coast of South Australia, but sporadically further west.

This paper deals only with southern Australian species of *Porphyra* and the related genus *Porphyropsis*. It is hoped that this presentation of the species will stimulate cultural studies to elucidate further their relationships.

Genus PORPHYRA C. Agardh

Key to Southern Australian Species

1. Blades delicate, rose-pink, ovate to lanceolate, epiphytic on certain brown (or red) algae in the upper sublittoral ..... *P. woolhousiae* Harvey

1. Blades lanceolate or ribbon-like, becoming umbilicate, grey- to red- or dark-purple, growing on rock or hard substrates 2

2. Thallus fairly tough, retaining its form when old, shrinking on drying and not adhering strongly to paper; usually over 45 μm thick; carposporangial‡ groups prominent, scattered, with vegetative cells among the groups; spermatangia occurring irregularly around the margin ..... *P. columbina* Montagne

2. Thallus usually delicate, disintegrating when old, adhering closely to paper and not markedly shrinking on drying; usually 20–30 μm thick; carposporangial groups usually not prominent; spermatangia occurring in (usually) narrow, elongate strips, extending inwards from the apical and side margins of the thallus ..... *P. lucasii* Levring

Porphyra woolhousiae Harvey 1863, pl. 265. J. Agardh 1883: 59. De Toni 1897: 15; 1924: 12. Guiler 1952: 84. Lucas 1909: 20; 1929: 15.

FIGS 1, 2

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‡ Although the true nature of the reproductive bodies in *Porphyra* is not fully understood, the classical terms carposporangia and spermatangia are used here to avoid confusion (Conway 1964).

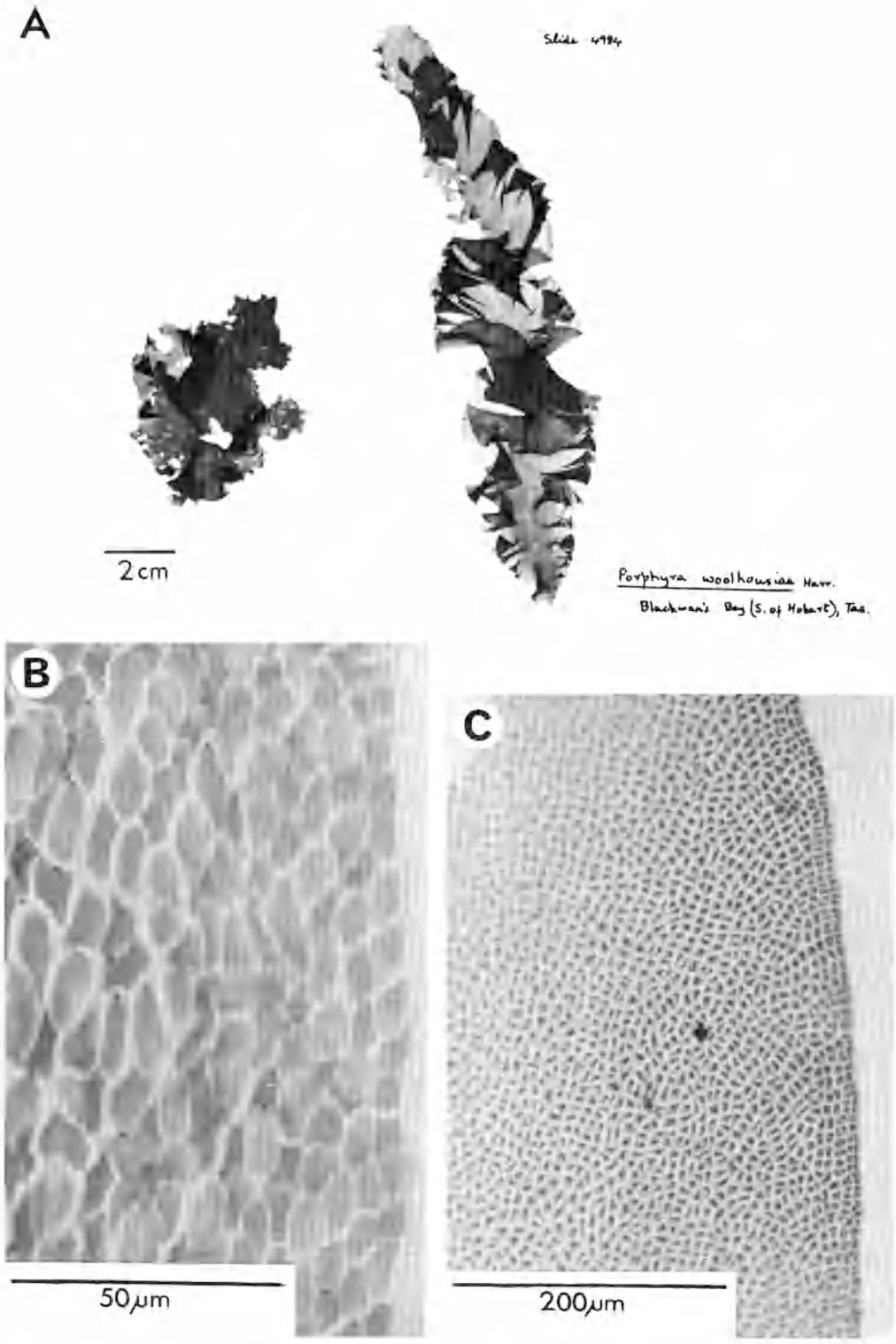

Fig. 1. *Porphyra woolhousiae*. *A*. Blackman's Bay, Tas. (ADU, A44234). *B*. Thallus margin, from the type. *C*. Thallus with margin (A44234).

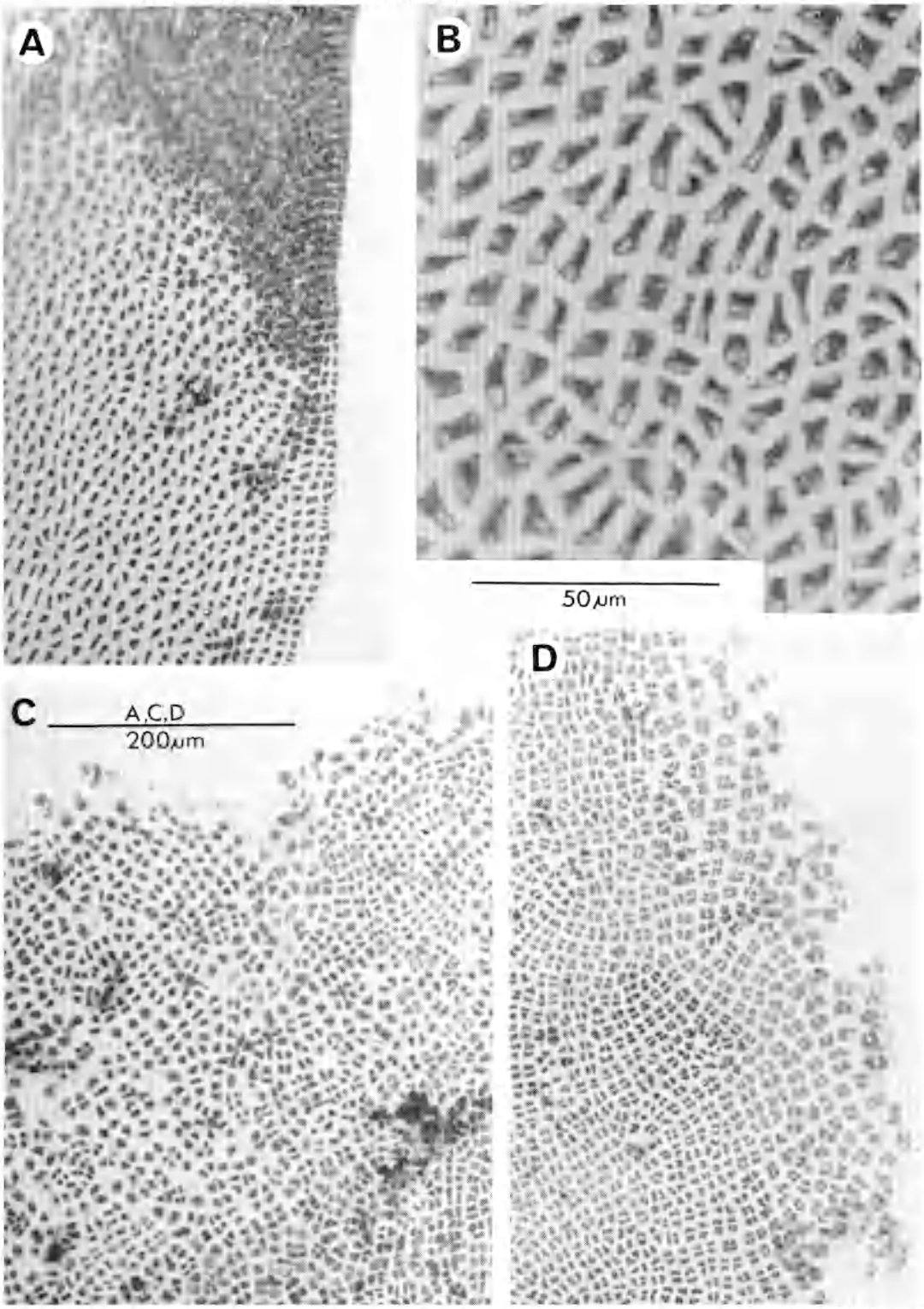

Fig. 2. *Porphyra woolhousiae*. *A*. Thallus with area of darkly-staining reproductive cells. (Blackman's Bay, Tas., ADU, A44234). *B*. Cell arrangement in older part (A44234). *C*. Thallus margin with liberation of reproductive bodies (St Kilda, S. Aust., ADU, A42722). *D*. Margin with spermatangia (A42722).

Thallus (Fig. 1*A*) epiphytic on brown algae or rarely on red algae, to 17 cm high and 4 cm broad, from irregularly ovate or cuneate-elongate when young, to broadly expanded or elongate with curved margins which are gently convolute in older plants (e.g. the type), delicate, with one to a few blades arising from a rhizoidal holdfast, rose-red to rose-purplish.

Monostromatic, (12–) 16–24 μm thick, cells isodiametric to slightly elongate in sectional view, each with a single, laminate or stellate rhodoplast, with a pyrenoid. Growth by a marginal meristem (Figs 1*B,C*, 2*A*) and by intercalary divisions: margins meristematic, with anticlinal rows of cells; older parts with cells often in rows but becoming irregular, with cells often polygonal or angular (Figs 1*B*, 2*B*), some rounded to ovoid, often with adjacent cells unequal in size. Marginal cells isodiametric to slightly elongate, angular, 6–10 μm across; cells in older parts iso-diametric to twice as long as broad, 10–16 (–20) μm across.

Reproductive bodies (Fig. 2*A,C*) formed in marginal areas, apparently singly, spherical to slightly ovoid, 12–17 μm across, usually with a stellate rhodoplast.

Spermatangia (Fig. 2*D*) forming well defined, irregular, patches near the thallus margins, the whole patch when mature tending to deliquesce with numerous spermatangia irregularly arranged; spermatangia originally formed in packets of (16–) 32–64, in two tiers, individually 2–4 μm across.

Type locality: Tasmania.

Type: Herb. Harvey, TCD (presented by Miss Woolhouse of Sheffield).

Distribution: As well as the type, this species is known from St Kilda, S. Aust., on *Gigartina*(?) on *Posidonia*, 1½ m below low tide level (*S. Lewis*, 23.viii.1972; ADU, A42722); Mallacoota, Vic., on *Scytothamnus australis* (*Ducker* and *King*, 15.ii.1970; MELU, 20652); Deal I., Bass Strait, on *Perithalia caudata* (*King*, 23.xi.1969; MELU, 21357); Curtis I., Bass Strait, on *P. caudata* (*King*, 8.ii.1971; MELU, 21358); and from Blackman's Bay (S. of Hobart), Tas., drift (*Tyler*, Oct.(?) 1973; ADU, A44234).

The type of *P. woolhousiae* is a well-developed specimen to 15 cm high, as in the Blackman's Bay, Tas., specimen, whereas St Kilda specimens are 2–4 cm high, the Mallacoota specimens are only 1–2 cm high and those from Bass Strait less than 1 cm high; the latter appear to be juvenile. All these, including the type, show similar cell structure and presence of marginal growth on young parts and often also on mature thalli. This marginal meristem is not apparent on the other southern Australian species or on most other species placed in *Porphyra*. A fragment of the type studied is not fertile, but the other specimens show characteristic spermatangial groups which tend to deliquesce, and from marginal areas the contents of each cell appear to be liberated as a reproductive body. *P. woolhousiae* has a typical *Porphyra* base with one or a few fronds attached by rhizoids from the basal thallus cells, and in most features agrees well with *Porphyra*. If, however, it is confirmed that the carposporangia are formed singly, then relationships with the genus *Porphyrella* Smith & Hollenberg (1943, p. 215) must be considered, though Conway & Wylie (1972) have shown that the New Zealand *Porphyra subtumens* does not form packets of carposporangia.

While it is desirable that mature plants on *Macrocystis*, corresponding to the type, be studied in detail, and their reproduction followed in culture, the other records are sufficiently similar to be placed under *P. woolhousiae* with some confidence. Most are epiphytic on brown algae, either on marginal spines or on spinous branchlets, and this habitat may be characteristic for the species.

P. woolhousiae has been recorded from New Zealand (Levring 1955, p. 412), followed by D. J. Chapman (1962, p. 129), V. J. Chapman (1969, p. 20) and Adams (1972, p. 67). However Adams, following notes of E. Conway in CHR, expresses doubt as to whether the New Zealand records are not *P. columbina* in an abnormal habitat.

The New Zealand specimens growing on *Macrocystis* (and possibly *Ecklonia* and *Scytothamnus*) need further comparison with the Australian plants referred to *P. woolhousiae*. Ones from Hokio Beach, Levin, N.Z., on *Macrocystis* (*Moore*, 17.xi.1946; CHR. 55566), determined by Levring (1955, p. 412) as *P. woolhousiae* (accompanied by notes of E. Conway (1971) that they might be young plants of *P. columbina*), agree fairly well with *P. woolhousiae* as now known from the Australian plants. They are similar in form, in thickness and cell arrangement, and in having a meristematic margin, but their reproduction is inadequately known.

Further comparisons between Australian and New Zealand specimens epiphytic on *Macrocystis* are clearly needed.

Skottsberg (1923, p. 4) recorded *P. woolhousiae* from the Falkland Islands, also on spines of *Macrocystis*, and his account shows similarities with the above description; details are not adequate for a full comparison. Hamel (1928, p. 55) recorded it from Kerguelen I., and Pujals (1963, p. 8) gives records from South America.

Porphyra columbina Montagne 1842: 14; 1845: 33, pl. 9, fig. 2. J. Agardh 1883: 70, pl. II, figs 65–66. V. J. Chapman: 1969: 22. Dawson, Acleto and Foldvic 1964: 32, pl. 61*B*. Guiler 1952: 84. Hamel 1928: 51. Kuetzing 1849: 693; 1869: 29, pl. 80e,f. Laing 1928: 39, figs 1–7. Levring 1953: 464, figs 2–4; 1955: 410; 1960: 29. Pujals 1963: 8.

Wildemania columbina (Mont.) De Toni 1897: 22.

P. umbilicalis sensu Cribb 1954: 30.

FIGS 3, 4

Thallus fairly tough, varying from ribbon-like (Fig. 3*A*), often with undulate margins, to broader forms, sometimes furcate, and usually umbilicate (by loss of upper parts and basal proliferation) (Fig. 3*B*) on rough-water coasts. Thallus often markedly shrinking on drying and usually not adhering closely to paper. Variable in size and width, reaching 40 cm long and 30 cm across. Colour varying from grey-red to red-purple.

Monostromatic, 35–50 μm thick, cells isodiametric in section and with a single axile, pyrenoid-bearing, rhodoplast. Cells 10–15 μm across in surface view (Fig. 4*A*), isodiametric to slightly elongate, more or less in rows but becoming irregularly arranged, separated by a gelatinous matrix $\frac{1}{2}$–1 times as wide as cells.

Carposporangial groups prominent (Fig. 4*C*), of varying shades of red, forming irregular marginal areas with vegetative cells intermingled, (8–) 32–64 carposporangia per group, often giving an irregularly granular ("spotty") red appearance to reproductive areas.

Spermatangial groups (Fig. 4*B, C*) scattered among the carposporangial groups and in older plants occupying the marginal part of the thallus; not occurring in elongate strips as in *P. lucasii*.

Type locality: Auckland I. (*D'Urville*).

Type: PC (Herb. Montagne).

Distribution: From Elliston, S. Aust. to Sydney, N.S.W. and around Tasmania; New Zealand, Auckland Islands and other sub-antarctic islands.

P. denticulata Levring from southern Queensland is probably not distinct from *P. columbina* and represents the range extreme of *P. columbina*.

P. columbina is the commonest intertidal species of *Porphyra* in New Zealand and in eastern southern Australia, where it occurs at a lower to mid (sometimes upper) eulittoral level on rough-water coasts. In Australia it is essentially a winter form, persisting as late as December (rarely to February in Bass Strait) in cooler summers and reappearing in about May.

Porphyra lucasii Levring 1953: 469, figs 6*H–L*, 7.

P. umbilicalis sensu Guiler 1952: 84. Womersley 1950: 162.

FIGS 5, 6

Thallus usually fairly delicate, varying from lanceolate or ribbon-like (Fig. 5*A*) to broadly ovate or cordate (Fig. 5*B*), simple or irregularly laciniate or basally branched, sometimes becoming umbilicate from basal proliferation, usually adhering to paper and not shrinking on drying; to 10 cm long and 15 cm broad, margin smooth to undulate.

Monostromatic, 20–30 μm thick, cells with a single axile, pyrenoid-bearing, rhodoplast. Cells 8–15μm across in surface view (Fig. 6*A*), mostly irregularly arranged, separated by gelatinous matrix $\frac{1}{2}$–1 times as wide as cells.

Carposporangial groups (Fig. 6*C*) usually not prominent, covering areas around the spermatangial strips toward the margin of the thallus, without conspicuous intermingled vegetative cells, about 8 carposporangia per group. Carposporangial groups often apparently developing later than spermatangial strips, thus giving an impression of dioecism.

Spermatangial groups (Fig. 6*B, C*) occurring as well-marked elongate strips (Fig. 5*B*) extending in from the apical regions and side margins of the thallus; strips from a few mm to 2 cm long, 1–5 mm broad. Margin becoming "fringed" following shedding of spermatangial strips.

Type locality: Bunbury, W. Aust.

Type: Herb. Levring, Gotebürg. (Isotype in ADU, A42700).

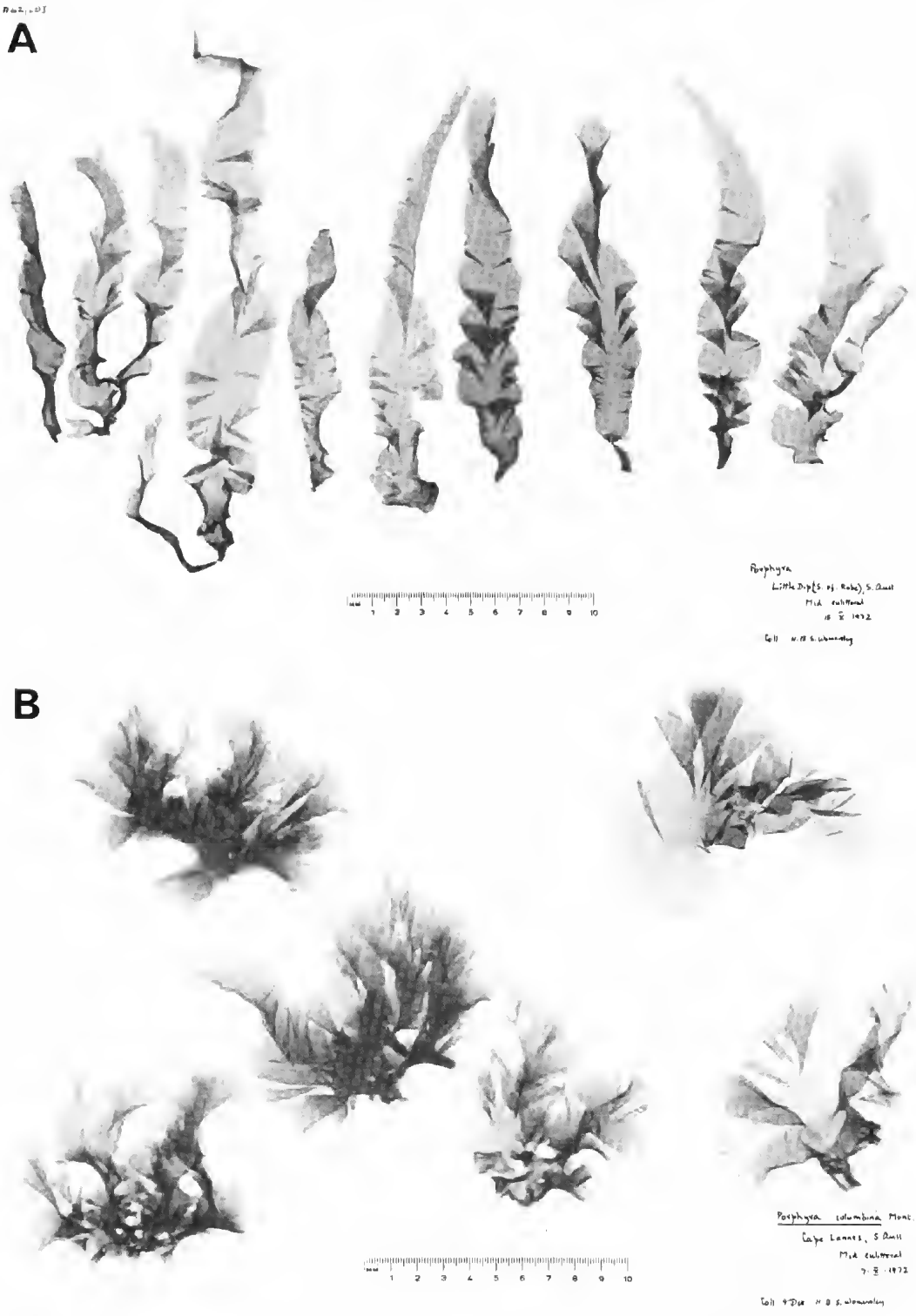

Fig. 3. *Porphyra columbina*. *A*. Ribbon-like forms, early winter. Little Dip, Robe, S. Aust. (*Womersley*, 15.v.1972; ADU, A42203). *B*. More umbilicate forms from spring. Cape Lannes, S. Aust. (*Womersley*, 7.x.1972; ADU, A42768).

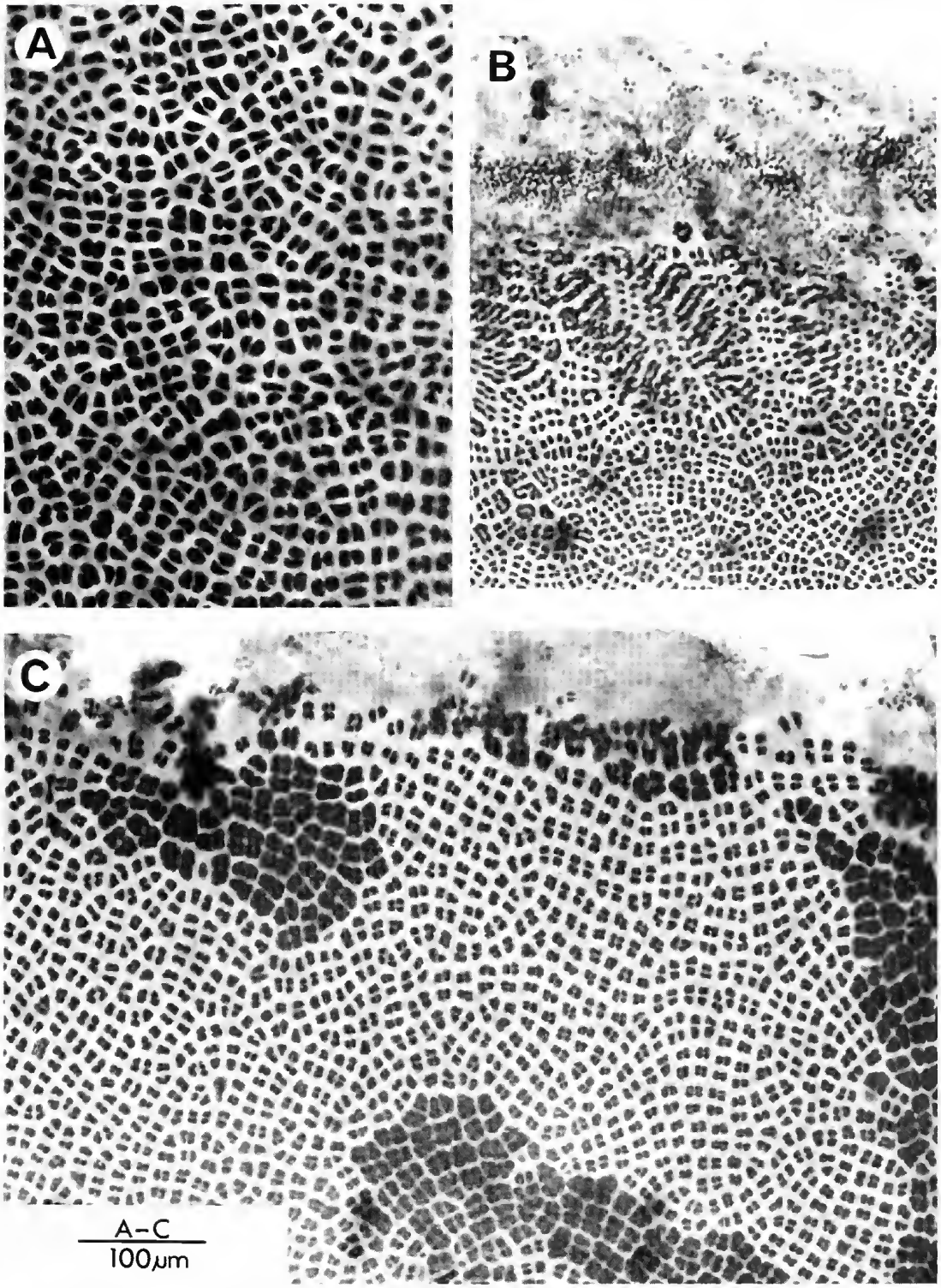

Fig. 4. *Porphyra columbina*. *A*. Vegetative cells. Nora Creina, S. Aust. (*Womersley*, 3.ix.1971; ADU, A39559). *B*. Spermatangial marginal area (A39559). *C*. Area with carposporangial groups and young spermatangia (A39559).

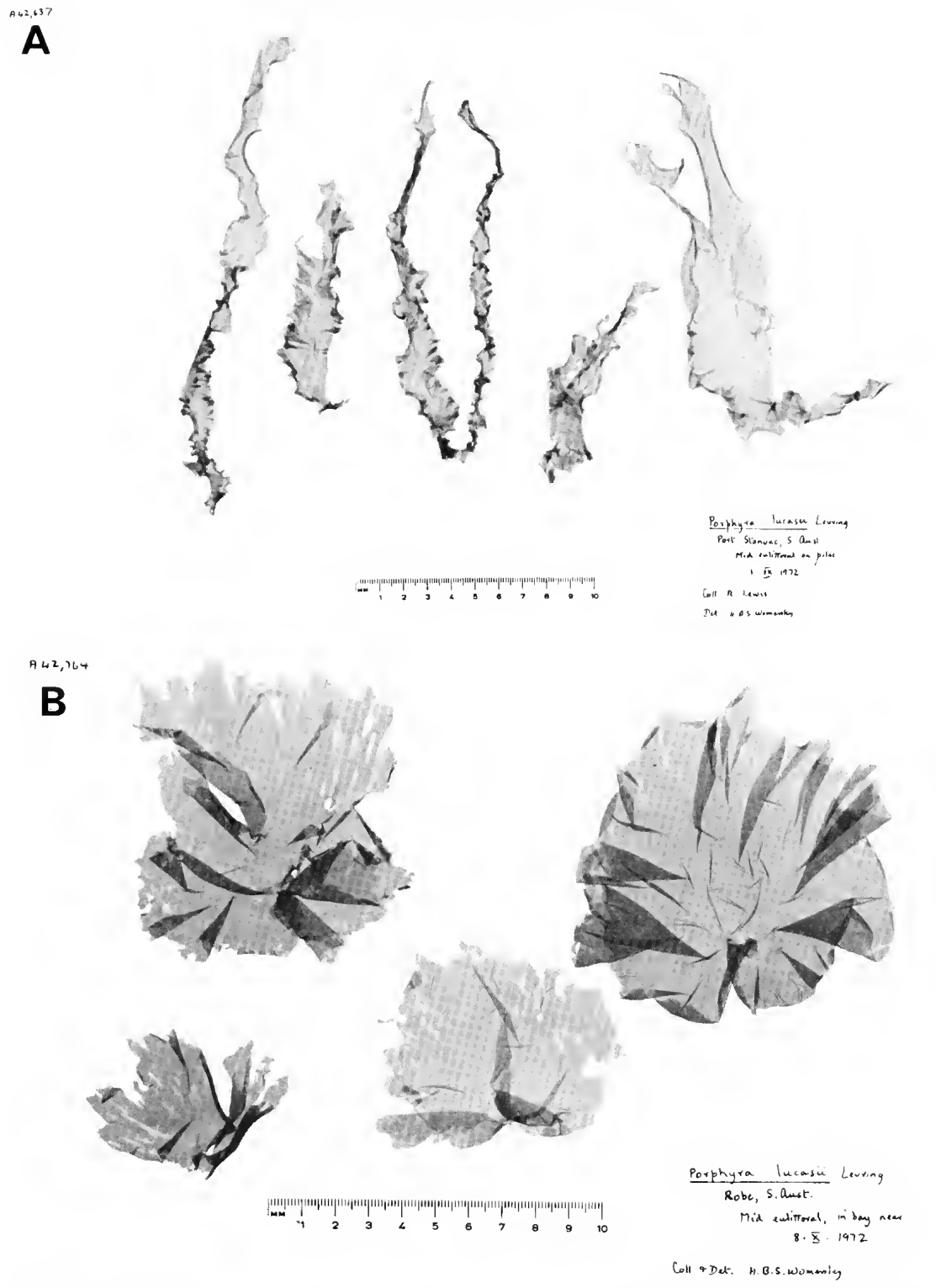

Fig. 5. *Porphyra lucasii*. A. Ribbon-like forms. Port Stanvac, S. Aust. (*Lewis*, 1.ix.1972; ADU, A42637). *B*. Broadly ovate forms showing spermatangial strips. Robe, S. Aust., in bay (*Womersley*, 8.x.1972; ADU, A42764).

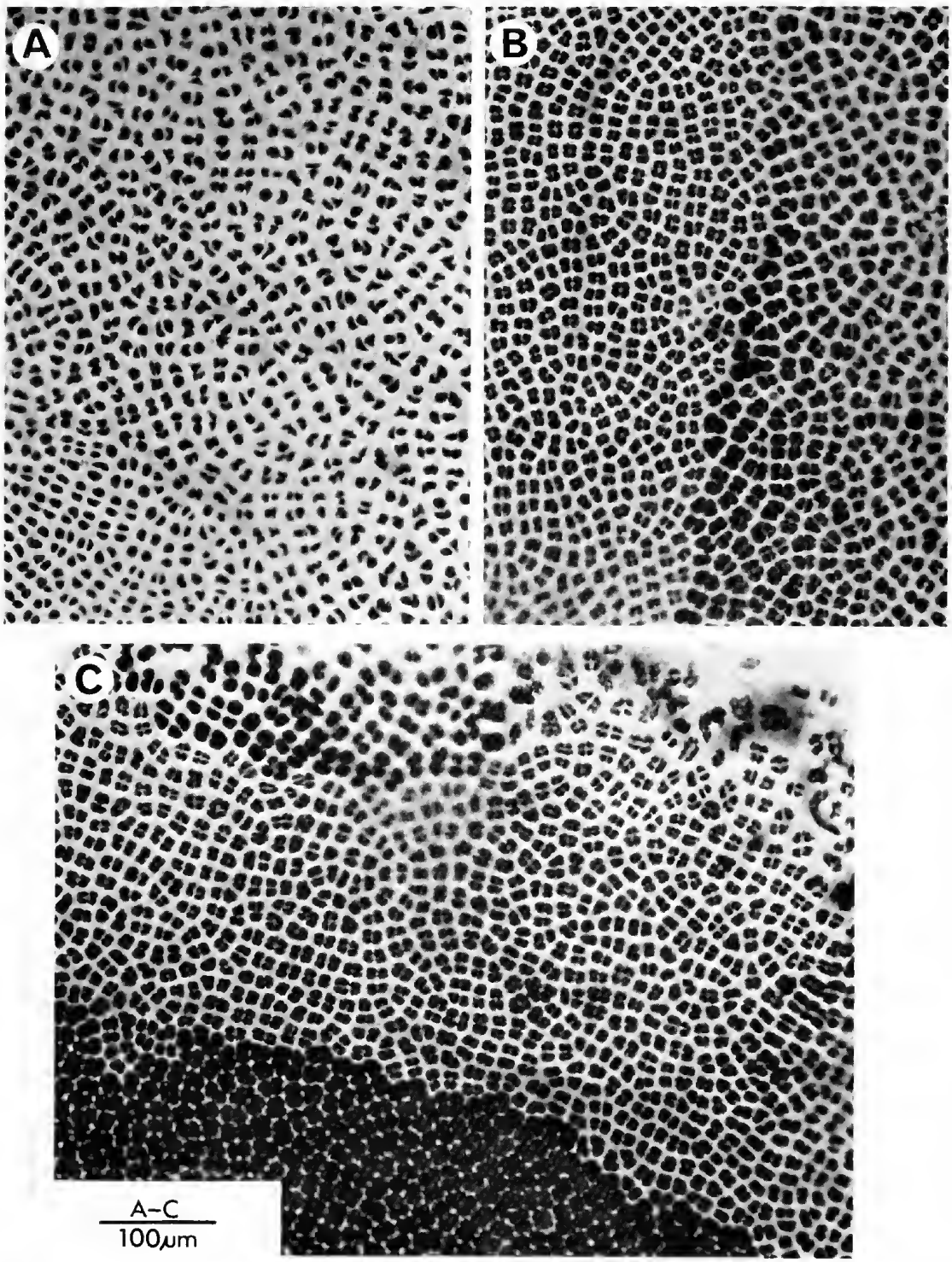

Fig. 6. *Porphyra lucasii*. *A*. Vegetative cells (ADU, A42764). *B*. Edge of a spermatangial strip with vegetative and carposporangial cells on the right (A42764). *C*. Part of a spermatangial strip releasing spermatia above and with carposporangial groups below (A42764).

Distribution: From Cottesloe, W. Aust. to Western Port Bay, Vic. and the north and east coasts of Tasmania.

P. lucasii is the common *Porphyra* of calm to moderately rough waters, being replaced by *P. columbina* where surf action is strong. It is essentially a winter plant of the mid to upper eulittoral, with old plants being found in October. *P. lucasii* is found within calmer bays such as Port Phillip Bay and Western Port, Vic., whereas *P. columbina* occurs on rough-water coasts.

Genus PORPHYROPSIS Rosenvinge

Porphyropsis minuta sp. nov.

Thallus epiphytic on certain Rhodophyta with a firm surface, developing from a subparenchymatous holdfast to form a hollow, sub-spherical to ovoid bladder (Fig. 7*A*), later opening above to form irregular, monostromatic membranes often with convolute margins. Color greenish-brown to purplish, not rose-red.

Bladders up to 1 (–2) mm across, torn membranes to 5 (–8) mm high and across. Cell divisions intercalary. Holdfast 50–100 (–200) μm across, formed of irregularly arranged cells without rhizoidal extensions. Cells of bladder (Fig. 7*B, C*) often paired or in fours following division, and lying in rows more or less at right angles, sometimes becoming irregularly arranged; membrane about 10 μm thick, cells 3–5 μm across and rounded to somewhat elongate in surface view, slightly ovate in sectional view. Rhodoplast apparently filling the cell, without a pyrenoid.

Monosporangia (Fig. 7*B*) formed from the whole contents of cells near the margin of the membranes, subspherical to ovoid, 5–7 μm across.

Thallus in Rhodophytis epiphyticus, solido superficie, ex subparenchymato base ortus, primum vesicam cavam, subglobosam vel ovoideam formans deinde superne membranas irregulares monostromaticasque saepe margine convoluto producens. Color brunneo-viridis vel purpureus, sed nunquam carneus.

Vesicae ad 1 (–2) mm latae, membranae laceratae ad 5 (–8) mm altae et latae. Divisura cellularum intercalaris. Basis ad 50–100 (–200) μm lata, ex cellulis sine projecturis rhizoideorum irregulariter compositis formata est. Cellulae vesicae saepe binae vel quaternae post divisionem, seriatim plus minusve rectangulatae, interdum irregulariter compositae: membrana circa 10 μm crassa, cellulis ad 3–5 μm latis et aspectu frontali globosis vel aliquantum elongatis, in sectione transversali parum ovoideis. Rhodoplastus ut videtur, cellulam complet, pyrenoide absenti.

Monosporangia subglobosa vel ovoidea, 5–7 μm lata, in cellulis prope marginem membranarum formata.

FIG. 7

Type locality: Pearson I., S. Aust., on *Pterocladia capillacea*, upper sub-littoral (*Specht*, 17.ii.1960).

Type: ADU, A24525.

Distribution: From Garden I., W. Aust. around southern Australia to Bateman's Bay, N.S.W., epiphytic on *Pterocladia capillacea* in upper sublittoral (and pools) on rough-water coasts, and occasionally on *Plocamium angustum*, *P. mertensii* and *Delisea pulchra* in similar habitats.

P. minuta agrees well with *P. coccinea* in the holdfast, form and development of the bladder, and in reproducing apparently only by monosporangia. The cells of *P. minuta* are similar in size to those in *P. coccinea* but are arranged in distinct rows more or less at right angles, in contrast to both *P. coccinea* from Europe (Rosenvinge 1909, p. 69, fig. 9) and *P. coccinea* var. *dawsonii* Hollenberg & Abbott (1968, p. 1239, fig. 5a–c) from California, where the cells are more irregularly arranged but are grouped into elongate, somewhat lenticular patches. The life-history and relationships of the latter taxon have been discussed by Murray, Dixon & Scott (1972), and it is desirable that the Australian plant should be studied in culture.

A further difference is that in *P. minuta* the whole contents of cells near the margins are liberated as monospores, whereas in *P. coccinea* the monospores are cut off from the parent cell by a curved wall, a residual cell remaining when the monospore is liberated. Also, in *P. coccinea* some holdfast cells form rhizoidal extensions whereas this has not been observed in *P. minuta*. The colour of *P. minuta* is always a greenish-brown-purple, never rose-red as in *P. coccinea*.

The only other southern hemisphere record of *Porphyropsis* is by Adams (1972, p. 68) who reported *P. coccinea* var. *dawsonii* from New Zealand. This taxon (e.g. CHR 248053 from Kaikoura, N.Z.; *Parsons*, 13.xi.1973) has numerous ligulate fronds from a clumped base, each with descending rhizoids. It is not a *Porphyropsis*, but more closely related to *Porphyra woolhousiae*.

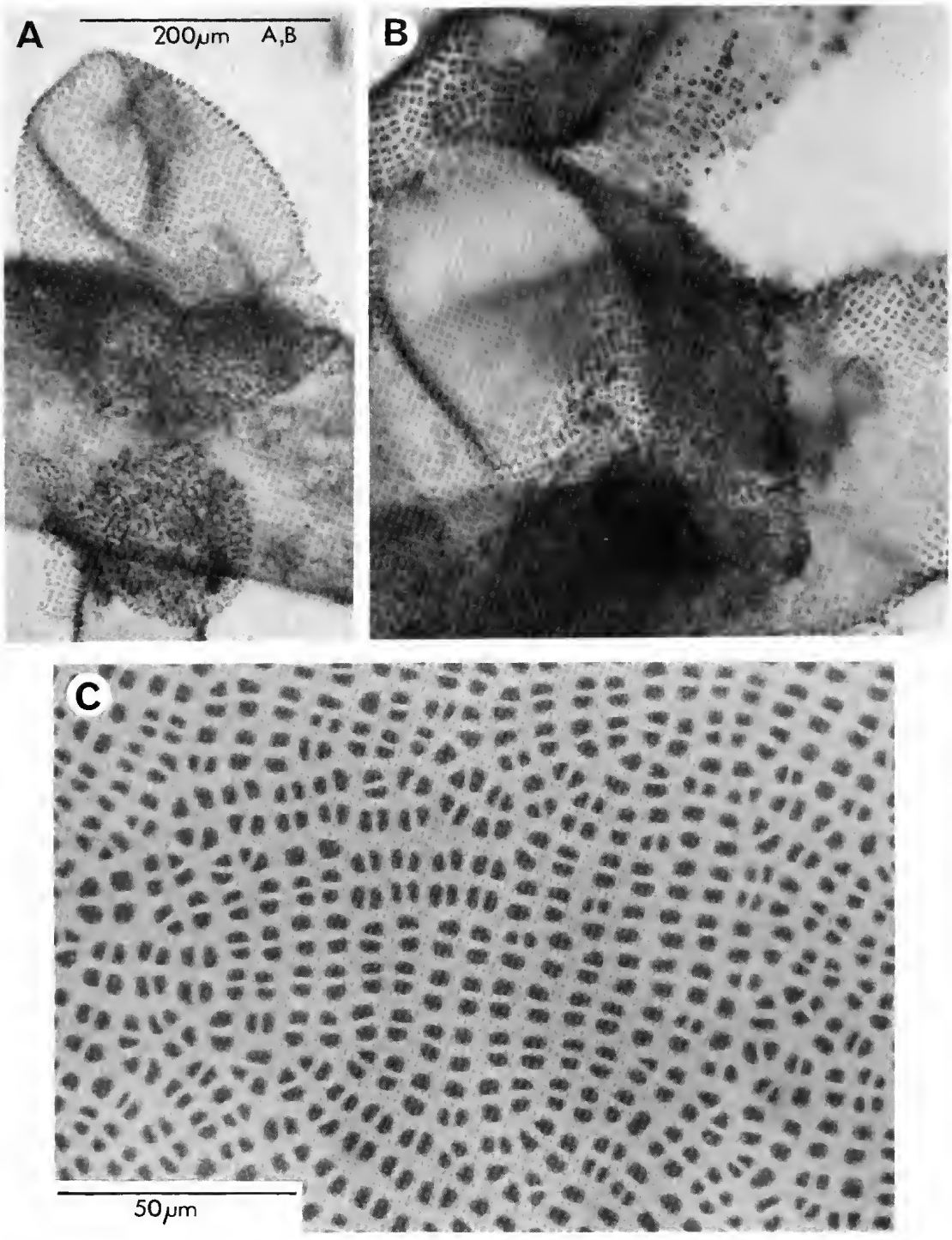

Fig. 7. *Porphyropsis minuta*. *A*. Small plants, on *Pterocladia*. *B*. Older membrane, with some cells releasing monosporangia. *C*. Cell arrangement. (All from the type, ADU, A42525.)

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